

## Muscle Growth and Distribution in Fattening Steer of Different Breeds

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### ABSTRACT

The breed patterns in growth and distribution of muscle were studied using three breeds of beef cattle entering fattening phase. This study involved 23 grass-fed steer Brahman, 24 Hereford and 22 Brahman x Hereford crosses with a live weight range of 300 to 600 kgs. An allometric Huxley model was used to study the growth and distribution patterns of muscle tissue within wholesale cut. There were several cuts in which the muscle growth coefficients were significantly different among breeds. Comparisons of muscle weight distribution at log natural of 75 kg side muscle + bone weight (4.313 kg) generally showed significant between-breed differences. Herefords tended to have more muscles in their wholesale cuts than Brahmans and/or Brahman x Hereford crosses, except the muscles in Tenderloin, Rib Set and Chuck. Brahmans had heavier Topside and Silverside than Herefords and Brahman x Hereford crosses and the differences were maintained at log natural of 114 kg side muscle + bone weight (4.733 kg). At this heavier weight, there was a general tendency for Brahmans to have more muscle in their wholesale cuts than the Brahman x Hereford steers, except the muscle in Loin and Neck + Sticking.

*Key words: steer, fattening phase, muscle growth, muscle distribution*

### INTRODUCTION

Saleable beef yield and its distribution within carcass have been intensively studied (Priyanto *et al.*, 1999; Mukai *et al.*, 2004; Hafid & Priyanto, 2006; Vieira *et al.*, 2006; Priyanto *et al.*, 2009). At lower fatness, it was reported that cattle with larger frame size had better yield percentages of saleable beef, if compared to that with smaller frame size (Priyanto *et al.*, 1999; Bidner *et al.*, 2009). Such variations in beef yield were associated primarily with maturity type differences because of the differential growth patterns of their carcass tissues (Priyanto *et al.*, 1999; Priyanto *et al.*, 2009). It is the carcass' muscle contributing predominantly to the yield of saleable beef. Significant between breed differences were reported in muscle growth and distribution when the muscle in wholesale cut was related to the total muscle within carcass despite the differences were relatively small (Shahin *et al.*, 1993; Mc Gee *et al.*, 2007).

Maturity type might be regarded as the fat-free carcass weight (carcass muscle + bone) at which cattle show a propensity to fatten. Purchas *et al.* (2002) used fat-free carcass weight as an effective adjustment factor

in breed comparison for muscularity and muscle to bone ratio. In relation to the exacting specifications of modern beef, such variations in muscle growth and distribution become commercially very important. The following study was undertaken to examine the influence of beef cattle breed on muscle tissue and its distribution throughout the wholesale cuts relative to fat-free carcass weight in fattening steer.

### MATERIALS AND METHODS

This study involved 69 grass-fed steers, comprising 23 Brahmans, 24 Herefords and 22 Brahman x Hereford Crosses which had enter, or were progressing along, their fat deposition phase. The steers were sequentially slaughtered at approximately 300, 400, 500, and 600 kg live-weight. All steers were fasted but access to water 24 hours prior to slaughter. Following dressing, the carcasses were divided into two sides, weighed and then chilled at 3 °C for 24 hours. The right sides were broken down into 15 wholesale cuts, namely thin flank, loin, tenderloin, rump, thick flank, topside, silverside, shank, point end (PE) brisket, navel end (NE) brisket, shin, blade, rib set, chuck, neck + sticking (AUS-MEAT, 2003). The cuts were then dissected into muscle, fat, intermuscular (IM) and subcutaneous (SC) fats, bone and connective tissue. The weights of the carcasses, the hot and chilled sides, wholesale cuts were recorded. All dissection products, including muscle, IM fat, SC fat,

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bone and connective tissue from each cuts were weighed and recorded. The computations of total muscle, muscle within wholesale cut and side muscle + bone weights were based on recovered weights of the right side.

### Statistical Analysis

An allometric model,  $Y = \alpha X^\beta$  (Huxley, 1932), was used to study the growth patterns of the muscle tissue. In order to obtain a linear relationship, the equation was transformed into log natural form. Breed effects on the relationship between the weight of muscle in the wholesale cut and the weight of side muscle + bone were examined using the following model:

$$\ln Y_{ij} = \ln \alpha + \text{Brd}_i + \beta \ln X_{ij} + \beta (\text{Brd})_i \ln X_{ij} + E_{ij}$$

Where

$Y_{ij}$  = muscle weight in wholesale cut of the  $j$ th animal from the  $i$ th breed

$\alpha$  = intercept

$\text{Brd}_i$  = fixed effect of the  $i$ th breed

$X_{ij}$  = side muscle + bone weight of the  $j$ th animal from the  $i$ th breed

$\beta$  = regression coefficient of  $Y_{ij}$  on  $X_{ij}$

$\beta (\text{Brd})_i$  = regression coefficient of the  $i$ th breed

$E_{ij}$  = residual error of the measurement of  $Y_{ij}$  assumed to be normally distributed around a mean of zero with a variance of  $\sigma^2$

This analysis allowed comparisons of breed regression coefficients as suggested by Kaps & Lamberson (2004), and estimates of dependent variables ( $Y$ 's) at a particular independent variable ( $X$ ). In order to obtain more

accurate results, the dependent variables were estimated using breed regressions at a particular  $X$  value and compared between breeds.

Because the carcass weight range covered both traditional (light weight) and specific (heavy weight) markets, it was of particular interest to compare the  $Y$  values at two different values of the independent variable ( $X$ ), one where the carcasses suitable for the traditional market and one where they were suitable for the specific (hotel, restaurant and institution) market. The traditional market prefer carcasses averaging 200 kg which correspond to 75 kg of side muscle + bone, while the specific market prefers carcasses averaging 300 kg or 114 kg side muscle + bone weight.

### RESULTS AND DISCUSSION

The use of side muscle + bone weight as a regressor in allometric relationships of tissues in the side and in the wholesale cuts is a sound basis for indicating maturity patterns among breed types. Relative to side muscle + bone weight, muscle growth within wholesale cut showed few breed variations. There were several cuts in which the muscle growth coefficients were significantly different among breeds (Table 1) but the differences were small and did not follow any particular pattern.

As shown in Table 2, comparison of muscle weight distribution at log natural of 75 kg side muscle + bone weight (4.313 kg) indicated that Herefords had significantly ( $P < 0.05$ ) more muscle in thin flank, loin, shank, brisket and blade than Brahman and or Brahman x Hereford crosses. Conversely, the Herefords had significantly ( $P < 0.05$ ) less muscle in tenderloin, rib set and

Table 1. Allometric relationship between muscle weight of the wholesale cut ( $Y$ ) and side muscle + bone weight ( $X$ ),  $\ln Y = \ln a + b \ln X$

Wholesale cut	Growth coefficient ( $b \pm SE$ ) <sup>†</sup>			$R^2$
	Hereford	Brahman	Brahman x Hereford	
Thin flank	0.921 $\pm$ 0.116	1.203 $\pm$ 0.121	0.953 $\pm$ 0.123	0.78
Loin	1.012 $\pm$ 0.051	1.038 $\pm$ 0.053	1.076 $\pm$ 0.054	0.95
Tender loin	1.065 $\pm$ 0.050	1.002 $\pm$ 0.053	0.936 $\pm$ 0.053	0.95
Rump	0.998 $\pm$ 0.061	1.093 $\pm$ 0.064	1.063 $\pm$ 0.065	0.93
Thick flank	0.951 $\pm$ 0.053	0.867 $\pm$ 0.056	0.922 $\pm$ 0.056	0.93
Topside	0.833 $\pm$ 0.030 <sup>a</sup>	0.936 $\pm$ 0.032 <sup>b</sup>	0.897 $\pm$ 0.032 <sup>ab</sup>	0.98
Silverside	0.989 $\pm$ 0.036	0.996 $\pm$ 0.038	0.975 $\pm$ 0.039	0.97
Shank	0.801 $\pm$ 0.041 <sup>ab</sup>	0.796 $\pm$ 0.044 <sup>a</sup>	0.916 $\pm$ 0.044 <sup>b</sup>	0.95
PE brisket	1.128 $\pm$ 0.086 <sup>ab</sup>	1.283 $\pm$ 0.090 <sup>b</sup>	0.983 $\pm$ 0.091 <sup>a</sup>	0.89
NE brisket	1.161 $\pm$ 0.058 <sup>a</sup>	1.340 $\pm$ 0.061 <sup>b</sup>	1.169 $\pm$ 0.061 <sup>a</sup>	0.95
Shin	0.861 $\pm$ 0.129	0.989 $\pm$ 0.135	0.933 $\pm$ 0.137	0.70
Blade	1.039 $\pm$ 0.044	1.103 $\pm$ 0.046	1.091 $\pm$ 0.047	0.96
Rib set	1.186 $\pm$ 0.068	1.269 $\pm$ 0.071	1.106 $\pm$ 0.072	0.94
Chuck	1.377 $\pm$ 0.063 <sup>b</sup>	1.249 $\pm$ 0.066 <sup>ab</sup>	1.185 $\pm$ 0.067 <sup>a</sup>	0.95
Neck + sticking	1.186 $\pm$ 0.067	1.101 $\pm$ 0.070	1.174 $\pm$ 0.071	0.93

Means in the same row followed by a different letter differ significantly ( $P < 0.05$ ); the weights of muscle within wholesale cut and side muscle + bone expressed in kg; <sup>†</sup> All breed regression coefficients highly significant ( $P < 0.01$ ).

chuck than the other two breeds. Meanwhile, Brahman had significantly ( $P<0.05$ ) heavier muscle in the topside and silverside than Herefords and their cross-bred cattle. At this side muscle + bone weight, the total muscle weight for Herefords, Brahman and Brahman x Hereford crosses were 59.96, 59.65, and 59.18 kg respectively.

At the heavier muscle + bone weight (log natural of 114 kg or 4.733 kg), there was a general tendency for Brahman to have more muscle in their wholesale cuts than Hereford and or Brahman x Hereford steers (Table 3). However, the Brahman had significantly ( $P<0.05$ ) less muscle in the loin and neck + sticking if compared with the other two breeds. Overall at this heavier muscle +

Table 2. Least-squared mean (LSMean) of muscle weight within wholesale cut adjusted to the overall mean of 4.313 kg side muscle + bone weight<sup>†</sup>

Wholesale cut	LSMeans±SE(kg) <sup>†</sup>		
	Hereford	Brahman	Brahman x Hereford
Thin flank	0.633±0.035 <sup>b</sup>	0.505±0.040 <sup>a</sup>	0.536±0.041 <sup>ab</sup>
Loin	1.616±0.015 <sup>b</sup>	1.542±0.018 <sup>a</sup>	1.579±0.018 <sup>ab</sup>
Tender loin	0.539±0.015 <sup>a</sup>	0.601±0.017 <sup>b</sup>	0.572±0.018 <sup>ab</sup>
Rump	1.618±0.018	1.655±0.021	1.637±0.021
Thick flank	1.326±0.016	1.343±0.018	1.299±0.019
Topside	1.786±0.010 <sup>a</sup>	1.819±0.010 <sup>b</sup>	1.790±0.011 <sup>a</sup>
Silverside	1.636±0.011 <sup>a</sup>	1.707±0.013 <sup>b</sup>	1.640±0.013 <sup>a</sup>
Shank	1.127±0.012 <sup>b</sup>	1.068±0.014 <sup>a</sup>	1.038±0.015 <sup>a</sup>
PE brisket	0.901±0.026 <sup>b</sup>	0.760±0.030 <sup>a</sup>	0.872±0.030 <sup>b</sup>
NE brisket	0.919±0.017 <sup>b</sup>	0.830±0.020 <sup>a</sup>	0.863±0.020 <sup>a</sup>
Shin	0.696±0.039	0.704±0.044	0.604±0.045
Blade	2.107±0.013 <sup>b</sup>	2.049±0.015 <sup>a</sup>	2.058±0.015 <sup>a</sup>
Rib set	1.134±0.020 <sup>a</sup>	1.207±0.023 <sup>b</sup>	1.159±0.024 <sup>ab</sup>
Chuck	1.598±0.019 <sup>a</sup>	1.681±0.022 <sup>b</sup>	1.679±0.022 <sup>b</sup>
Neck + sticking	1.527±0.020	1.471±0.023	1.513±0.023

Means in the same row followed by a different letter differ significantly ( $P<0.05$ ); † Expressed in log natural value.

Table 3. Least-squared mean (LSMean) of muscle weight within wholesale cut adjusted to the overall mean of 4.733 kg side muscle + bone weight<sup>†</sup>

Wholesale cut	LSMeans±SE(kg) <sup>†</sup>		
	Hereford	Brahman	Brahman x Hereford
Thin flank	1.019±0.043 <sup>b</sup>	1.009±0.040 <sup>b</sup>	0.936±0.040 <sup>a</sup>
Loin	2.040±0.019 <sup>b</sup>	1.977±0.018 <sup>a</sup>	2.030±0.018 <sup>b</sup>
Tender loin	0.985±0.019 <sup>ab</sup>	1.021±0.017 <sup>b</sup>	0.964±0.018 <sup>a</sup>
Rump	2.036±0.023 <sup>a</sup>	2.113±0.021 <sup>b</sup>	2.083±0.021 <sup>ab</sup>
Thick flank	1.725±0.020	1.707±0.018	1.686±0.019
Topside	2.135±0.011 <sup>a</sup>	2.212±0.010 <sup>c</sup>	2.166±0.011 <sup>b</sup>
Silverside	2.051±0.014 <sup>a</sup>	2.125±0.013 <sup>b</sup>	2.049±0.013 <sup>a</sup>
Shank	1.463±0.015 <sup>b</sup>	1.401±0.014 <sup>a</sup>	1.423±0.014 <sup>ab</sup>
PE brisket	1.373±0.032 <sup>b</sup>	1.298 ±0.030 <sup>ab</sup>	1.284±0.030 <sup>a</sup>
NE brisket	1.405±0.022	1.392±0.020	1.354±0.020
Shin	1.058±0.048	1.118±0.044	0.995±0.045
Blade	2.542±0.016	2.512±0.015	2.515±0.015
Rib set	1.631±0.025 <sup>a</sup>	1.739 ±0.023 <sup>b</sup>	1.623±0.024 <sup>a</sup>
Chuck	2.175±0.023	2.205±0.022	2.176±0.022
Neck + sticking	2.024±0.025 <sup>b</sup>	1.932±0.023 <sup>a</sup>	2.005±0.023 <sup>b</sup>

Means in the same row followed by a different letter differ significantly ( $P<0.05$ ); † Expressed in log natural value.

bone weight, the total muscle of Herefords, Brahmans and Brahman x Hereford crosses were 92.88, 93.55, and 91.55 kg respectively.

The present study indicated more muscle in the proximal hind limb region but less in the lumbar and shoulder regions from Brahman steer relative to Hereford steer and the breed differences were more apparent in the heavier side muscle + bone weight. Johnson *et al.* (2002) reported similar results that the larger Indicus steer tended to have more muscle particularly in the proximal hind limb if compared to the smaller British steers.

Despite several studies suggest that breed effects are not large enough to have any important influence on muscle weight distribution, noticeable differences in the muscle weight of combined cuts were observed when two extreme breed types were compared. Double-muscled type cattle were obviously superior in the deposition of muscle particularly in the proximal hind limb region if compared with normal cattle (Gotoh *et al.*, 2009). Moreover, it was reported that the double-muscled cattle had almost twice the fiber number of the normal cattle, indicating a more extensive hyperplasia of muscle fibers during embryonic development (Wegner *et al.*, 2000).

At a similar maturity level, carcasses from large and small breeds differ in their weights and sizes. Therefore, differences in maturity should be expected when muscle weight distribution between breeds is compared at a constant total side muscle + bone weight as used in this study.

Based on the demonstrated development of muscle from hind-limb to fore-limb (Priyanto *et al.*, 2009), the smaller Hereford breed would have more muscle in the fore-limb while the larger Brahman breed would have more muscle in the hind-limb. In this study, because Brahmans were less mature than Herefords, the heavier muscle of the hind limb in the Brahman breed was not necessarily associated with superior muscle development in the region. Therefore, it was argued that breed differences in muscle weight distribution, especially in the proximal hind-limb, were not due to breed superiority in muscle development but rather to maturity and size differences.

In the heavier weight of carcass side (165 kg), Hereford and Brahman had similar total muscle weights but they had obviously less total muscle if compared to Brahman x Hereford crosses (Priyanto *et al.*, 1999). Meanwhile, this study indicated better carcass muscling of Brahman steer relative to the cross-bred steer when adjustment was made at similar fat-free carcass weight (maturity). The remarkably faster growing fat relative to muscle in fattening steer as reported by Priyanto *et al.* (2009) suggest earlier mature of Brahman relative to Brahman x Hereford cross breeds. Therefore, at similar carcass weight the Brahman steer would have deposited more carcass fat and consequently contained less carcass muscle.

## CONCLUSION

In fattening steer, there were significant differences in muscle growth coefficient of several cuts. However,

the differences were small and did not follow any particular pattern. At constant side muscle + bone weight, breed differed significantly in muscle weight distribution and the differences were more apparent in the heavier side muscle + bone weight. The breed differences in muscle weight distribution, especially in the proximal hind-limb, were not necessarily associated with breed superiority in muscle development but rather to maturity and size differences.

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